Technology and Integrated Discipline Engineering Services (TIDES) Representative Task Order (RTO) Overview

A set of representative task orders (RTOs) has been assembled to cover key elements of the TIDES Statement of Work (SOW) content. The missions described in the RTOs do not represent actual NASA missions nor do they reflect a future proposed mission. The purpose of these representative task orders is to provide the Offeror a sampling of the type of tasks to expect under this Indefinite Delivery/Indefinite Quantity (IDIQ) contract. Offerors shall prepare a response to each RTO using the specified instructions in section L of the RFP.

The TIDES RTOs are to be evaluated as separate and unrelated problems. No actual work, described under the statements of work in these RTOs, is to be performed by the Offeror. **The Offeror shall prepare a response to each RTO summarized below:**

RTO-1 **Engineering Support for Long Scanner Mission**

The Long Scanner Mission (LSM) is a Goddard Space Flight Center (GSFC) mission currently in the process of spacecraft integration. The contractor is tasked to provide engineering and Guidance Navigation and Control (GN&C) Systems support to the LSM Systems, Attitude Control Systems (ACS) and Propulsion Teams. Focus on: guidance, navigation, and control; and propulsion engineering.

RTO-2 **Engineering Support for the Alice Tech Demo Sat (ATDS) Mission**

The ATDS Mission is a Goddard Space Flight Center (GSFC) mission currently in the design phase. The contractor is tasked to provide engineering support to design, fabricate, test and deliver avionics boxes. Focus on: guidance, navigation, and control hardware engineering.

TIDES Representative Task Order #1
Engineering Support for Long Scanner Mission

Task Background

The Long Scanner Mission (LSM) is a Goddard Space Flight Center (GSFC) mission that will launch a satellite to use high-resolution visible light instruments to scan along a designated longitude line. The project is being managed by GSFC, the observatory is being built and tested at GSFC, and the satellite will launch from Cape Canaveral. The mission will be operated via the GSFC Mission Operations Center. The instrument suite is being built and assembled by an external partner and is scheduled to be delivered to GSFC by April 1, 2015 to be integrated with the Observatory. A team of GSFC system and subsystem engineers has brought the Observatory through the System Integration Review (SIR). Following successful completion of the SIR, part of the GSFC civil servant engineering team was reassigned to support a new, critical mission. This task is to provide engineering and GN&C Systems support to the LSM Systems, ACS and Propulsion Teams as defined below.

Table 1 lists the mission characteristics of the LSM. At completion of the SIR, all sensors, actuators and electronics boxes described in Table 2 have been procured or built in-house, and all structures and ground support equipment (GSE) have been delivered. Interface Control Documents and End Item Data Packages for all components have been delivered as well. Component level testing is complete, and subsystems are ready for delivery to the spacecraft. The flight and ground system software is complete and prepared for testing. The propulsion system is a spacecraft module, shown in Figure 2, which was built offline. It has been successfully proof and acceptance tested and is ready for integration to the spacecraft. Electrical and thermal closeout work still needs to be completed on the propulsion system. The project team successfully completed the System Integration Review on March 6, 2015 and is ready to begin spacecraft integration. The satellite is expected to launch on February 25, 2017. If the LSM is not prepared to launch in February 2017 this critical window of opportunity to launch is lost.

Task Period of Performance

The task order will be awarded effective April 1, 2015, with a period of performance from April 1, 2015 through May 31, 2017.

Assumptions

- Spacecraft environmental testing is expected to last four (4) months
- Travel is required to launch site for spacecraft preparation and launch activities
- All work under the task will be performed at GSFC unless otherwise stated

Long Scanner Mission Requirements

The LSM key mission characteristics are shown in the table below.

Table 1 – Long Scanner Mission Characteristics

Mission Orbit	
Circular	Geosynchronous
Inclination	60°
Longitude	Maintained within 0.5° box. Maneuvers will move equatorial crossings by 30° W every six months.
Mission Lifetime	Minimum 5 years
Launch System	Atlas V
Launch Mass	1161 kg
Delta-V Requirements	GTO→GEO = 1450 m/s On Station = 200 m/s Total delta-V = 1650 m/s
Attitude Control	3-axis stabilized, nadir-pointing
Pointing Accuracy	10 arc-sec, 1 sigma
Pointing Stability	0.1 arc-sec over 1 sec
Communications	
Routine	X-Band
Command	X-Band
Telemetry	
Clock Accuracy:	5 millisecond knowledge to UTC
Risk Classification	B

Table 2 – Long Scanner GN&C Component List

ACS Components	Propulsion Components
4 – 50 N-m-s reaction wheels	2 – 0.992 m^3 spherical titanium propellant tanks Fill fraction = 0.62 at 50°C
2 – Ring laser gyroscopes, dual serial output	8 – 22N delta-V thrusters
3 – Star trackers	3 – Isolation valves
16 – Coarse sun sensors	4 – Service valves
2 – Redundant avionics boxes, which provide power to some ACS and Propulsion components	2 - Filters

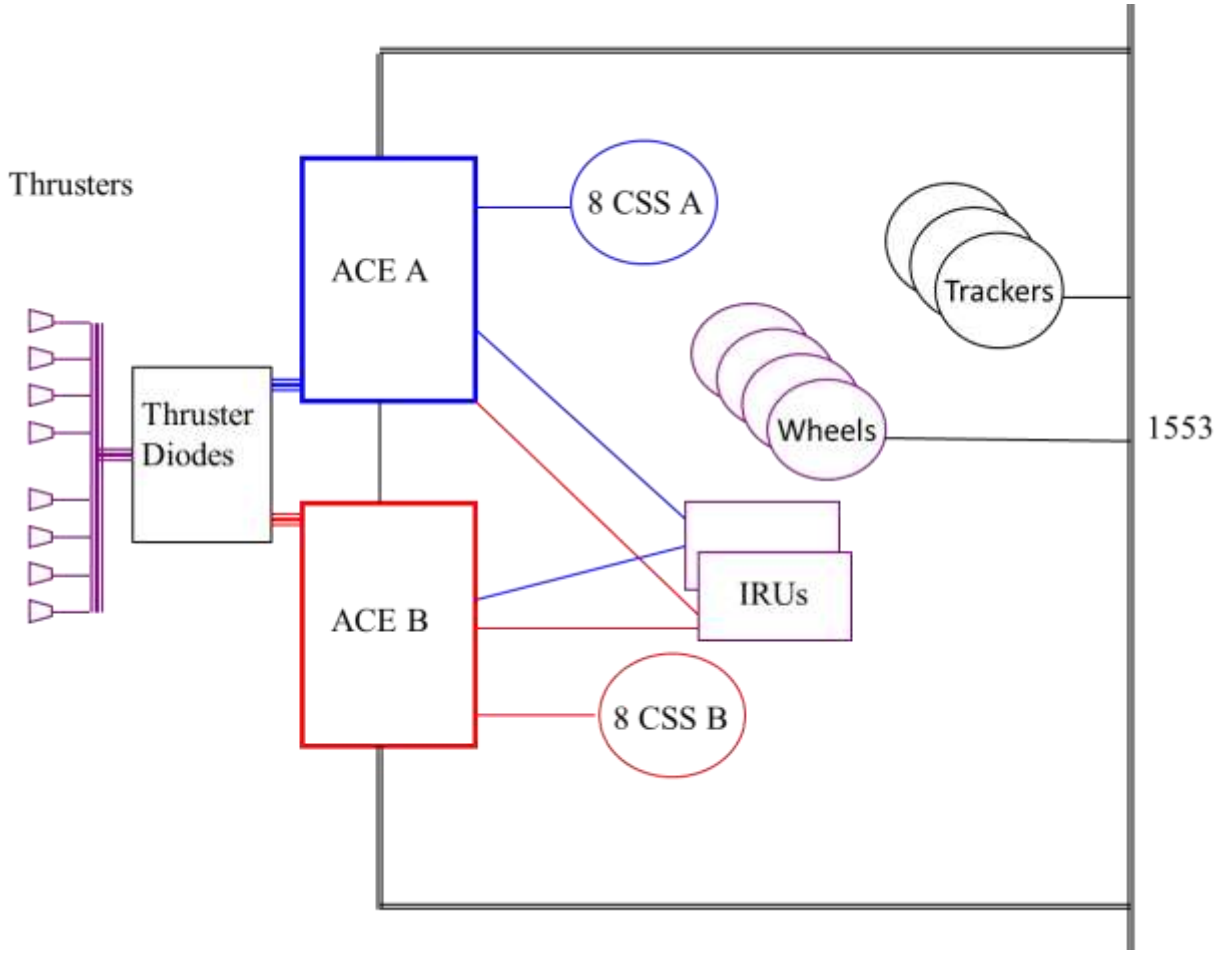

Figure 1 – Attitude Control System Schematic

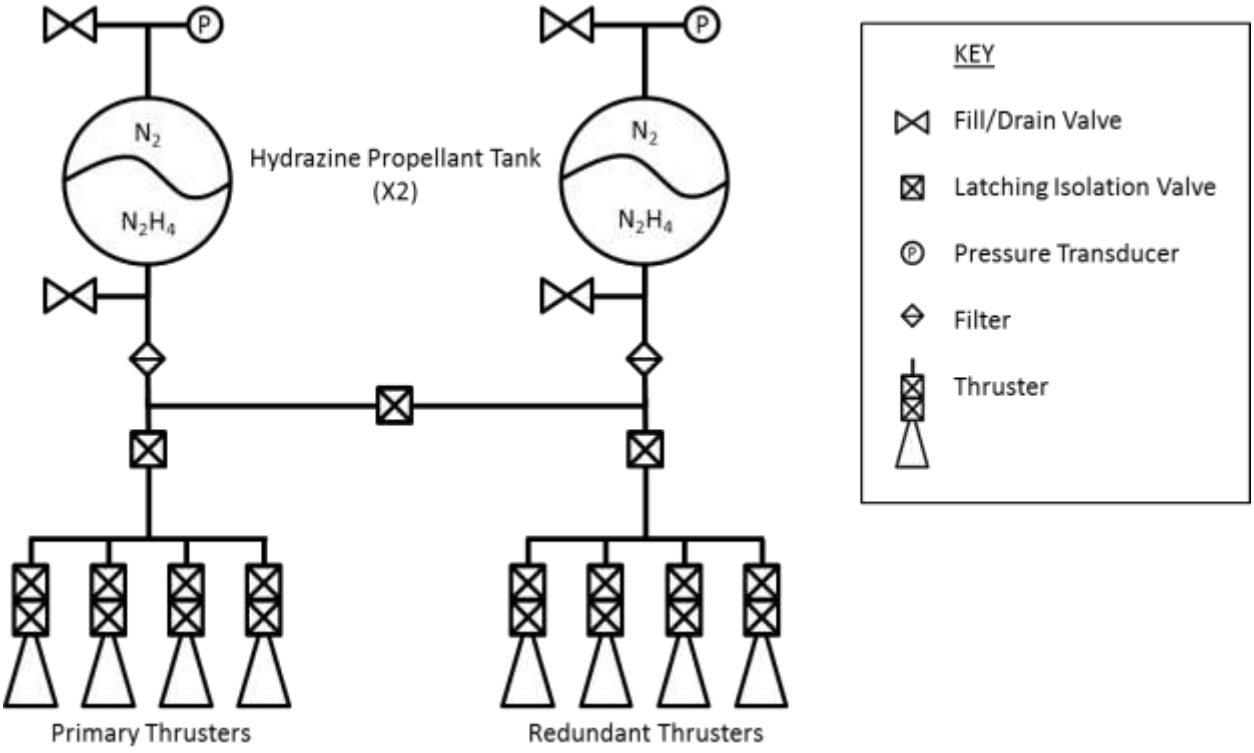

Figure 2 – Propulsion System Schematic

Statement of Work

Contractors shall staff the GN&C Systems Engineer position and the ACS and Propulsion Teams. The contractor shall provide engineering support for activities related to spacecraft integration, testing, launch, and commissioning as described in the subtasks below.

Applicable Documents

NPR 7120.5E	NASA Program and Project Management Processes and Requirements
GSFC-STD-1000E	Goddard Space Flight Center (GOLD) Rules for the Design, Development, Verification, and Operation of Flight Systems
NASA/SP-2007-6105	NASA Systems Engineering Handbook

NASA-STD-8719.17 NASA Requirements for Ground Based Pressure Vessels and Pressurized Systems

The LSM documents listed below are complete and released at the start of this task.

LSM-001 "Mission Requirements Document"
LSM-002 "Mission Concept Report"
LSM-003 "Ops Concept Document"
LSM-004 "Spacecraft Interface Definitions"
LSM-005 "Systems Requirements Document"
LSM-006 "ACS Algorithms Document"
LSM-007 "Spacecraft Integration Plan"

Subtask 1: GN&C Systems Engineering

The contractor shall complete the following GN&C Systems Engineering tasks.

1. Provide technical leadership, coordinating and guiding the work of the ACS and Propulsion teams.
2. Provide updates to documentation and schedule information for the mission to the project-managed Configuration Management System.
3. Provide resource estimates to the Mission Systems Engineer.
4. Support integration of all GN&C components onto the existing spacecraft structure.
5. Conduct tests on flight hardware as part of a comprehensive testing campaign.
6. Perform risk identification and assessment.
7. Complete requirements verification.
8. Support scheduled reviews as members of the engineering team.
9. Assist Ground Systems team in formulation of mission simulation scenarios.
10. Participate in three (3) mission simulations in preparation for launch.
11. Travel to the launch site to support final comprehensive testing prior to launch.
12. Support the launch of the spacecraft, both at the launch site and in the Mission Operations Center through commissioning of the spacecraft 60 days after launch.
13. Conduct activities in support of commissioning, including planning and conducting orbit raising delta-V maneuvers.
14. Identify and address technical problems and recommend solutions.

Deliverables

- Monthly status reports
- GN&C Schedule with monthly updates
- GN&C Risk List with monthly updates
- GN&C Requirements Verification Matrix
- GN&C Section of the Comprehensive Performance Test Plan
- GN&C Section of the Test Readiness Review Presentation Package
- GN&C Section of the Operational Readiness Review Presentation Package
- GN&C Section of the Flight Readiness Review Presentation Package
- GN&C Section of the Pre-Ship Review Presentation Package

*All deliverables are due in accordance with the contractor's proposed schedule as approved by GSFC.

Subtask 2: Attitude Determination and Control Engineering

The contractor shall complete the integration and testing of the Attitude Control System. GSFC onsite test facilities and ground support equipment are available to perform these tasks. The contractor is not responsible for technician support for this subtask. The contractor shall also complete activities in preparation for launch as detailed below.

1. Generate test procedures based on existing test plans.
2. Provide engineering support for ACS hardware integration to the spacecraft.
3. Support spacecraft Comprehensive Performance Tests.
4. Analyze and evaluate test data to determine readiness of spacecraft for launch.
5. Analyze and evaluate test data to determine appropriate parameters to use in flight software.
6. Conduct final ACS stability analyses using tested mass properties and flexible mode information.
7. Provide ongoing support to the Goddard flight software team during testing.
8. Support scheduled reviews as members of the engineering team.
9. Assist Ground Systems team in formulation of mission simulation scenarios.
10. Participate in three (3) mission simulations in preparation for launch.
11. Travel to launch site to support final comprehensive performance testing prior to launch.
12. Support the launch of the spacecraft at the launch site and in the Mission Operations Center through commissioning.
13. Conduct activities in support of commissioning of the spacecraft 60 days after launch, including planning and conducting delta-V maneuvers.
14. Identify and address technical problems and recommend solutions.

Deliverables

- GN&C Requirements Verification Results
- ACS Stability and Performance Analysis Report
- GN&C Comprehensive Performance Test Procedures
- ACS Section of the Test Readiness Review Presentation Package

*All deliverables are due in accordance with the contractor's proposed schedule as approved by GSFC.

Subtask 3: Propulsion Engineering

The contractor shall complete the testing of the Propulsion System. GSFC onsite test facilities and ground support equipment are available to perform these tasks. The contractor shall supply technician support. The contractor shall also complete activities in preparation for launch as detailed below.

1. Recertify existing propellant loading cart for use on the LSM spacecraft.
2. Perform the following closeout work:
   a. Thermal closeout work, with the exception of blanketing.
   b. Electrical closeout work.
3. Perform functional testing of propulsion system once integrated with the spacecraft.
4. Assist Ground Systems team in formulation of mission simulation scenarios.
5. Participate in three (3) mission simulations in preparation for launch.
6. Perform propulsion system testing at the launch site to verify compliance with AFSPC safety requirements.
7. Load propellants.
8. Support scheduled reviews as members of the engineering team.
9. Support the launch of the spacecraft, both at the launch site and in the Mission Operations Center through commissioning of the spacecraft 60 days after launch.
10. Conduct activities in support of commissioning, including planning and conducting delta-V maneuvers.
11. Identify and address technical problems and recommend solutions.

Deliverables

- Propulsion System Functional Test Plan and Procedure
- Loading Cart Certification Package
- Propellant Loading Plan and Procedure

*All deliverables are due in accordance with the contractor's proposed schedule as approved by GSFC.

- End of RTO 1 -

TIDES Representative Task Order #2
Engineering Support for Alice Tech Demo Sat Mission

Task Background

The Alice Tech Demo Sat (ATDS) mission will build, launch, and operate a technology demonstration satellite in a highly elliptical lunar transfer-type orbit. The project is being managed by Goddard, and a Goddard team of engineers has developed a baseline GN&C system design and related requirements. All pertinent interfaces are determined. Hardware will be procured and final integration and testing of the spacecraft will be performed at Goddard facilities. The satellite is Class B and expected to launch in February, 2021. Mission CDR is scheduled for March 12, 2018. The satellite will be launched on an Antares Launch Vehicle, and will be 3-axis stabilized and inertially oriented.

Task Period of Performance

The task order will be awarded effective November 1, 2015, with a period of performance from November 1, 2015 through October 31, 2019.

Assumptions

- Support after October 31, 2019 will be provided on a different task.
- All design, analysis, testing, procedure, and interface information created by the contractor in the performance of this task shall be provided to the task holder upon request.

Avionics Box Requirements

The ATDS GN&C system block diagram is shown in Figure 1. Table 1 lists the GN&C components and interfaces. The avionics box must accept data from and issue commands to the suite of GN&C hardware, which includes some demonstration technology, as described in Table 1. Commands must be accepted from the Command and Data Handling (C&DH) avionics box, and data from the GN&C hardware must be relayed back to the C&DH. The two flight units shall be cross-strapped with the C&DH boxes as well as a portion of the GN&C hardware suite.

The following requirements shall apply to this task:

R-1. The avionics box shall operate off of the unregulated 28V spacecraft power.

R-2. The avionics box shall receive and process commands from the C&DH over the 1553 bus. Commands shall be in CCSDS format.

R-3. The avionics box shall process signals from the Attitude Control System (ACS), propulsion, and tech demo hardware and provide them to the on-board Attitude Control Software.

R-4. The avionics box shall provide a telemetry and data path via 1553 bus to the C&DH.

R-5. The avionics box shall generate the necessary commands and signals to operate the attitude control, propulsion, and demonstration hardware using 1553 and RS-422 interfaces as described in Table 1.

R-6. The avionics box shall communicate with a dedicated MEMS Thruster Control Unit via the RS-422 serial interface. Another vendor will supply the MEMS Thruster Control Unit.

R-7. The Avionics Box shall house and run the ACS flight software. The code will be automatically generated by Goddard civil servants using Simulink and provided to the contractor in the C Programming language.

R-8. The custom interface cards for the propulsion system shall provide switched 28V spacecraft power to drive the reaction engines, latch valves and pyro valves.

R-9. The final design provided by the contractor shall include two (2) inhibits to the firing of thrusters in order to meet NASA Wallops Flight Facility Range Safety guidance on handling hydrazine systems.

R-10. The custom interface cards shall provide a minimum thruster pulse width of 20 ms. The 5-Hz commanding rate in Table 1 is the rate that the card must process commands.

R-11. Flight parts shall be selected and processed in accordance with the requirements of EEE-INST-002. The minimum acceptable EEE Part grade for Flight use shall be Level 3.

All sampling and commanding rates provided should be considered minimum values, which may be increased if a design efficiency is thereby achieved. If any single requirement drives cost or schedule excessively, the task holder should be informed at the earliest opportunity so that the possibility of requirement adjustments can be fully considered.

The GN&C and technical demonstration hardware complement is shown in Table 1. Information about interfacing with this hardware will be included in the Project-provided Avionics Interface Control Document.

Table 1 – Alice Tech Demo Sat GN&C Component List

Component	Number of Units	Interface	Minimum Sample/ Command Rate
Reaction Wheel	4	MIL-1553	10 Hz
Reaction Engine (5-lb)	8	Switched unregulated 28V bus power	5 Hz
Propulsion Latch Valve	4		N/A
Propulsion Pyro Valve	4		N/A
Propulsion Pressure Transducer	3	Analog	1 Hz
Coarse Sun Sensor	16	Analog	1 Hz
Three-Axis Ring Laser Gyroscope	2	RS-422	20 Hz
Accelerometer (demo)	1	MIL-1553	20 Hz
APS Star Camera (demo)	4	MIL-1553	50 Hz
GPS Receiver (demo)	1	MIL-1553	1 Hz
Magnetometer (demo)	1	RS-422	20 Hz
MEMS Thruster Control Unit (demo)	1	RS-422	50 Hz

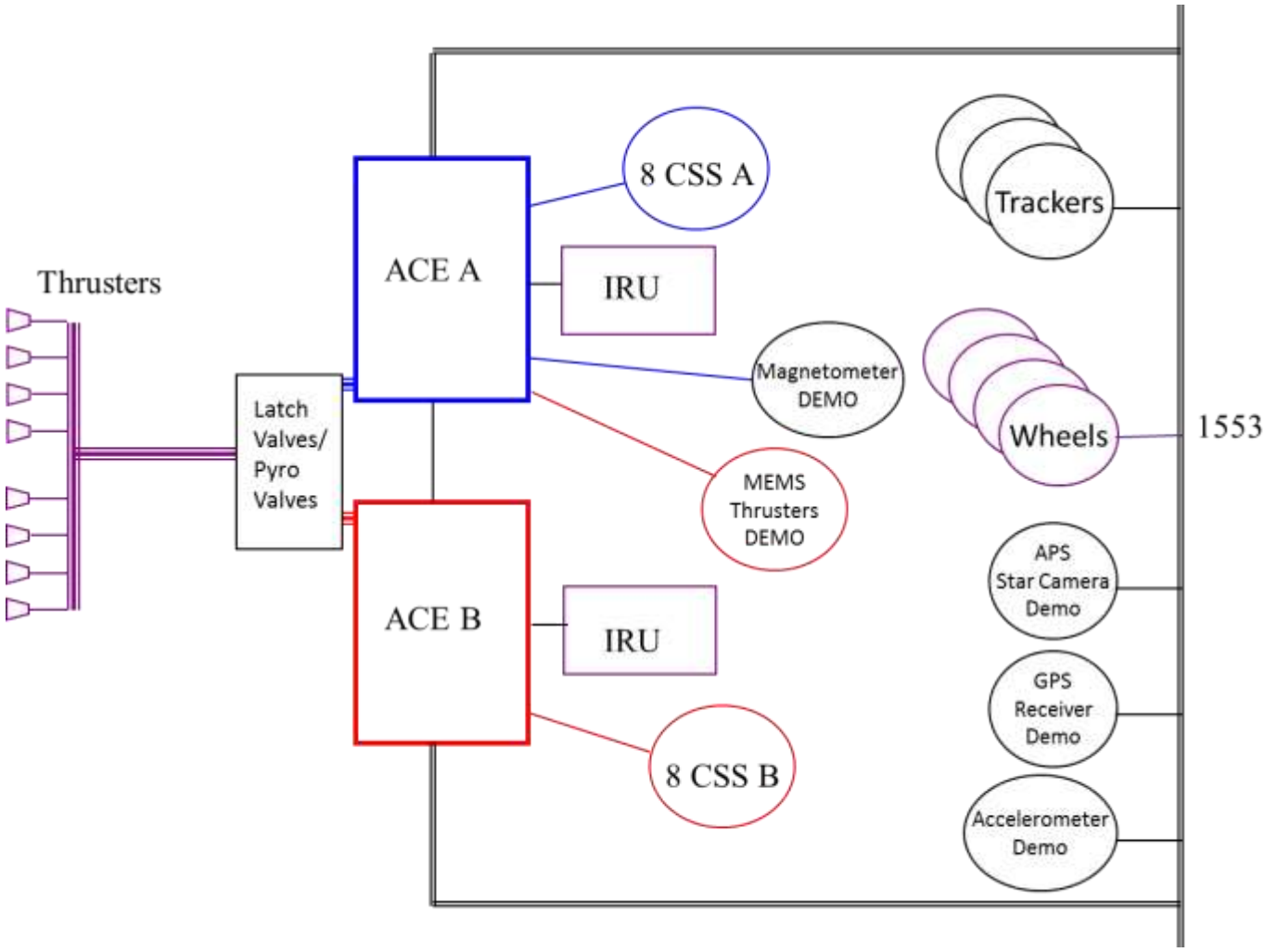

Figure 1 – Alice Tech Demo Sat GN&C Block Diagram

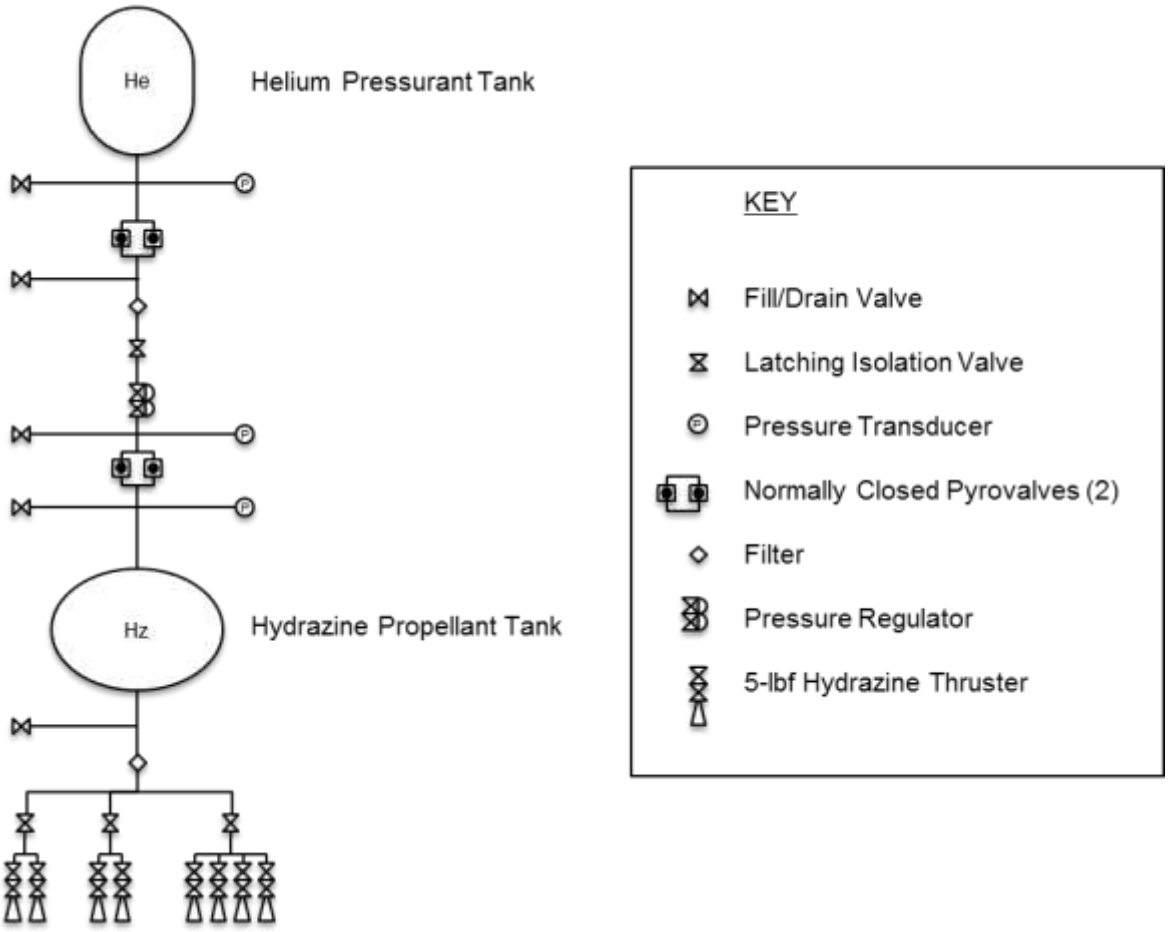

Figure 2 – Alice Tech Demo Sat Propulsion System Schematic

Statement of Work

The contractor shall design a custom avionics box to interface with ACS and Propulsion hardware, and build, test and deliver two flight units, an engineering test unit (ETU), and an engineering development (bread board) unit. The preliminary design shall be complete and validated on the EDU prior to the box-level Preliminary Design Review (PDR). After a successful box-level PDR, the task will continue into the box assembly phase, which will result in delivery of the three avionics boxes to the project. The engineering test unit shall be delivered no later than February 16, 2018, and the two flight boxes shall be delivered no later than October 31, 2019. See Table 2 in the Deliverables section for milestones in the task timeline. Support after flight box delivery will be managed as a different task.

Milestones:

Table 2 provides the key milestones for the task.

Table 2: Task Milestones

Milestone	Date (no later than)
Box Preliminary Design Review	January 2, 2017
EDU Delivery to Project	April 21, 2017
Box Critical Design Review	January 1, 2018
ETU Delivery to Project	February 16, 2018
Mission Critical Design Review	March 1, 2018
Flight Box 1 & 2 Delivery	October 31, 2019

Applicable Documents

NPR 7120.5E	NASA Program and Project Management Processes and Requirements
GSFC-STD-1000E	Goddard Space Flight Center (GOLD) Rules for the Design, Development, Verification, and Operation of Flight Systems
NASA/SP-2007-6105	NASA Systems Engineering Handbook
RSM2002C	Range Safety Manual for the Goddard Space Flight Center's Wallops Flight Facility
EEE-INST-002	Instruction for EEE Parts Selection, Screening, Qualification, and Derating
NASA-STD-8739.1	Workmanship Standards for Polymeric Application on Electronic Assemblies
NASA-STD-8739.2	NASA Workmanship Standard for Surface Mount Technology
NASA-STD-8739.3	Soldered Electrical Connections
NASA-STD-8739.4	Crimping, Interconnecting Cables, Harnesses, and Wiring
GSFC-WM-001B	Workmanship Manual for Electrostatic Discharge Control (ESD) (Excluding Electrically Initiated Explosive Devices)

The ATDS documents listed below are complete and released at the start of this task.

ATDS-001	"Mission Requirements Document"
ATDS-002	"Mission Concept Report"
ATDS-003	"Ops Concept Document"
ATDS-004	"Spacecraft Interface Definitions"

ATDS-005 "Avionics Interface Control Document"
ATDS-006 "Spacecraft Integration Plan"

Tasks:

The contractor shall complete the tasks listed below to design, build, test and deliver two flight units, an engineering test unit (ETU), and an engineering development (bread board) unit.

1. Perform circuit design and analysis
2. Perform circuit board layout
3. Perform FPGA coding, as required
4. Perform parts management to conform to EEE-INST-002
5. Provide Quality Assurance support during hardware fabrication and assembly
6. Assemble bread boards, ETU and flight circuit boards
7. Perform board-level and box-level functional testing
8. Perform structural and thermal design and analysis
9. Perform chassis fabrication and box assembly
10. Perform environmental testing of the engineering and flight boxes prior to delivery
11. Generate and provide documents and procedures as needed
12. Conduct Manufacturing Readiness Review(s)
13. Provide mass and power resource updates to the GN&C Systems Engineer
14. Manage Avionics Box budget and schedule
15. Participate in weekly telecons with the task monitor
16. Generate Monthly Reports including technical progress, cost and schedule performance, and programmatic issues

Deliverables:

Table 3 provides the deliverables for the task.

Table 3: Task Deliverables

Deliverable	Date (no later than)
Preliminary Structural and Thermal Model Delivery	May 15, 2016
Box Preliminary Design Review Package	Due 2 weeks prior to Box PDR
Timing and Signal Integrity Analyses	December 15, 2016
EDU Delivery to Project	April 21, 2017
Box Critical Design Review Package	Due 2 weeks prior to Box CDR
Manufacturing Readiness Review(s)	Prior to hardware build(s)
Printed Wiring Board Coupons	Due 2 weeks prior to start of Printed Wiring Board assembly
Mission Critical Design Review Package	Due 2 weeks prior to Mission CDR
ETU Delivery to Project	February 16, 2018
Flight Box 1 & 2 Delivery	October 31, 2019

- End of RTO 2 -

Representative Task Order Acronyms

ACE	Attitude Control Electronics
ACS	Attitude Control System
AFSPC	Air Force Space Command
APS	Active Pixel Sensor
ATDS	Alice Tech Demo Sat
C	Celsius
CCSDS	Consultative Committee for Space Data Systems
C&DH	Command and Data Handling
CDR	Critical Design Review
CSS	Coarse Sun Sensor
EDU	Engineering Development Unit
EEE	Electrical, Electronics, and Electromechanical
ETU	Engineering Test Unit
FPGA	Field Programmable Array
GEO	Geosynchronous Orbit
GN&C	Guidance Navigation and Control
GSE	Ground Support Equipment
GSFC	Goddard Space Flight Center
GPS	Global Positioning System
GTO	Geosynchronous Transfer Orbit
IDIQ	Indefinite Delivery Indefinite Quantity
IRU	Inertial Reference Unit
LSM	Long Scanner Mission
MEMS	Micro-electrical-mechanical Systems
NASA	National Aeronautics and Space Administration
RFP	Request for Proposal
RTO	Representative Task Order
SIR	System Integration Review
SOW	Statement of Work
TIDES	Technology and Integrated Disciplines Engineering Services
UTC	Coordinated Universal Time